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(71) Applicant: ERICSSON INC. [US/US]; One Triangle Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventor: DENT, Paul, W.; Stehags Prästgård, S-240 36 Stehags (SE).

(74) Agents: GRUDZIECKI, Ronald, L. et al.; Burns, Doane, Swecker & Mathis, P.O. Box 1404, Alexandria, VA 22313-1404 (US).

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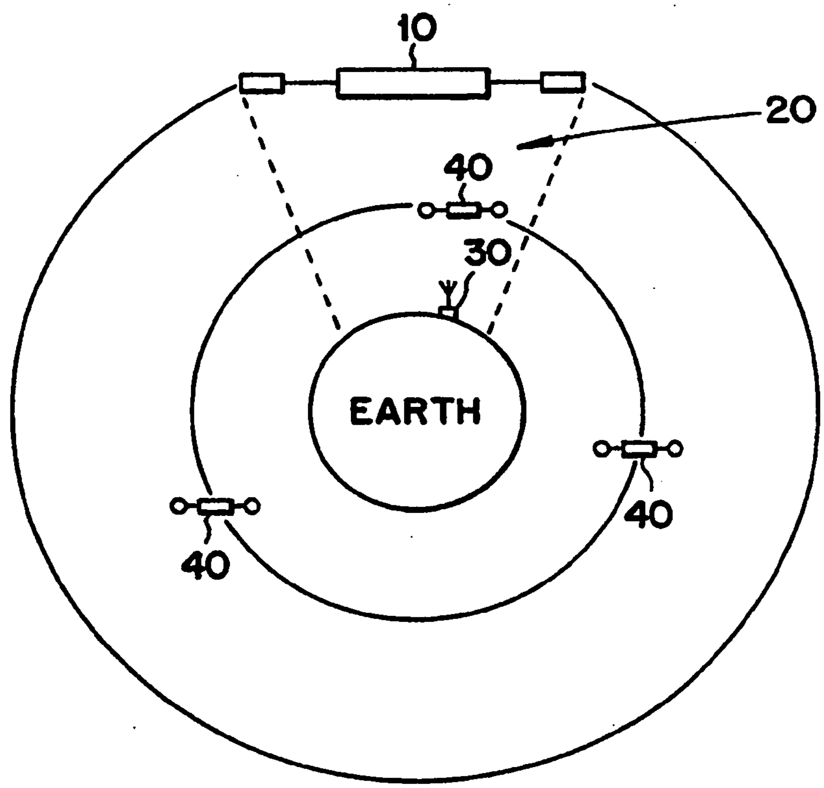
(54) Title: RADIOCOMMUNICATION SYSTEM USING GEOSTATIONARY AND NON-GEOSTATIONARY SATELLITES

(57) Abstract

A radiocommunication system and method using a combination of a geostationary (GEO) and a plurality of medium earth orbit (MEO) satellites are disclosed. First, a GEO satellite is launched to provide initial system capacity. Next, MEO satellites are successively launched into positions where they can supplement the coverage of the GEO satellite during peak traffic hours. Finally, when a sufficient number of MEO satellites are in place, the GEO satellite can provide the supplementary capacity.



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RADIOCOMMUNICATION SYSTEM USING GEOSTATIONARY AND NON-GEOSTATIONARY SATELLITES

BACKGROUND

The present invention generally relates to methods and systems for providing radiocommunications and, more particularly, to such methods and systems which use satellites to provide radiocommunications.

In the past, satellite systems for providing global coverage have been of one of three types, broadly classifiable by orbiting distance into geostationary (GEO), low earth orbit (LEO) and medium earth orbit (MEO). An example of a geostationary satellite communications system is the INMARSAT system (International Maritime Satellite Organization). One advantage of geostationary satellites is that they remain in a fixed position relative to the earth, and only four such satellites are required to illuminate the entire earth. A disadvantage of geostationary satellites is that they are very distant, needing high transmit power and large antennas to provide communications capacity and incurring about a 1/4 second, round-trip, signal propagation delay.

An example of a LEO system is the IRIDIUM system proposed by Motorola. An advantage of LEO systems is that the satellites are much closer to the earth, thereby providing improved communications. Since the satellites are closer to the earth, less transmitting power is needed for both the satellite and an individual user's transceiver. A disadvantage is that about 70 satellites are required to give 24 hour coverage to most points on the globe. Moreover, satellites in low earth orbits move quite rapidly relative to the earth, thereby causing high Doppler shifts and frequent handovers of communication from one satellite to the next.

An example of the compromise MEO system is the ODYSSEY satellite system proposed by TRW. The orbital altitude of MEO satellites lies between the GEO and MEO orbits, providing better communication quality than a GEO system, with less movement and Doppler shift than an LEO system. Moreover, MEO systems provide more or less 24 hour coverage to most points on the globe

using between 8 and 18 satellites which is much less expensive than the about 70 satellite LEO solution.

While the MEO solution represents a good compromise between conflicting requirements, it suffers from a practical disadvantage that almost all satellites must be in place before coverage is sufficient (in percentage of time available) to be considered attractive to subscribers. This lesson was learned from the GPS satellite navigation system, which is also a MEO solution. Thus, a considerable investment spanning a multi-year program is needed before significant revenue can be expected when implementing a MEO system.

Accordingly, it would be desirable to provide radiocommunication systems and methods which overcome the foregoing drawbacks of conventional LEO, MEO and GEO solutions.

SUMMARY

According to exemplary embodiments of the present invention a hybrid GEO/MEO solution begins life with the launch of a geostationary satellite that provides radiocommunication coverage to a region of major expected traffic growth, but has a limited capacity which is sufficient to support only an initial number of subscribers. This is followed by the successive launch of a number of MEO satellites. The MEO satellites can, initially, supplement the coverage of the geostationary satellite. Later, once sufficient MEO satellites are in orbit, the primary traffic burden can be relegated to the MEO satellites, with the GEO satellite performing a supplementary role. Finally, if desired, enough MEO satellites can be launched to provide all of the desired system capacity.

In this way, a major drawback of MEO systems, specifically the lengthy period between initial launching and sufficient capacity to reach profitability, is overcome since systems according to the present invention provide instant capacity by first launching a geostationary satellite.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and other, objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

Figure 1 illustrates a geostationary satellite orbiting the earth according to the present invention;

Figure 2 illustrates a geostationary satellite and several medium earth orbit satellites according to another exemplary embodiment of the present invention; and

Figure 3 shows a geostationary satellite and many medium earth orbit satellites according to an exemplary embodiment.

DETAILED DESCRIPTION

According to the present invention, Figure 1 shows a first satellite 10 which will be established in a geostationary orbit to provide the initial capacity of the system. Although limited in its capacity, this geostationary satellite 10 can provide sufficient capacity to serve a limited number of subscribers within a predefined geographical coverage or traffic area 20. Thus, for example, if a terminal unit 30 remains within the geographical coverage area 20 and is one of the limited number of subscribers served by geostationary satellite 10, the terminal unit 30 would expect to receive good service except, perhaps, at peak usage times.

During a second phase of system development, successive satellites 40 can be launched into a medium earth orbit as seen in Figure 2. For example, such an orbit could be a so-called harmonically synchronous orbit whereby the satellite orbits the earth an integral number of times in one sidereal day such that the ground track repeats. For example, an orbital radius of 16756 km (orbital height 10386 km) gives 4 orbits per sidereal day. Note that each of the medium earth orbit satellites 40 could have greater nominal capacity than the geostationary satellite 10 due to their relative proximity. Of course, a single medium earth

desirable to launch the geostationary satellite first to provide instant capacity, one or more medium earth orbit satellites could be launched before the geostationary satellite. Those skilled in the art will readily appreciate that many modifications and adaptations are contemplated by the present invention whose scope is defined by the appended claims including all equivalents thereof.

Claims:

1. A satellite communications system comprising:

at least one geostationary satellite and at least one medium earth orbiting satellite for providing radio communications to a plurality of remote subscriber terminals, in which the at least one geostationary satellite provides radio communications to said remote subscriber terminals during periods when the remote subscriber terminals cannot access one of said at least one medium earth orbit satellites.

2. A satellite communications system comprising:

a geostationary satellite which provides radio communication service to a plurality of remote subscriber terminals until a first medium orbit satellite is operational, wherein said first medium orbit satellite supplements the radio communication service of said geostationary satellite after the first medium orbit satellite is operational.

3. A system according to claim 2 wherein said first medium orbit satellite is disposed in a position to cover at least one peak traffic area at peak times of day.

4. A system according to claim 2 further comprising:

a plurality of additional medium earth orbit satellites which become operational after said first medium orbit satellite becomes operational, wherein said geostationary satellite directs its capacity to serve areas determined based on traffic and service capacity of the medium earth orbit satellites.

5. A system according to claim 1 in which said geostationary satellite is followed successively by an increasing number of medium earth orbit

satellites, said geostationary satellite providing one of: stand alone service to subscribers,
service to subscribers supplemented at peak periods by at least one medium earth orbit satellite, and service for gaps in coverage provided by said medium earth orbit satellites.

6. The system according to claim 5, wherein the service provided by said geostationary satellite is determined based on a number of medium earth orbit satellites in orbit.

7. A method of providing radiocommunication to a plurality of terminal units comprising the steps of:

launching a satellite into a geostationary orbit;

providing radiocommunication service to said plurality of terminal units using only said geostationary satellite prior to launching additional satellites;

launching a plurality of satellites into a medium earth orbit; and

providing radiocommunication service using both said geostationary satellite and at least one of said plurality of medium earth orbit satellites.

8. The method of claim 7 wherein said second providing step further comprises the steps of:

providing radiocommunication service using said at least one of said plurality medium earth orbit satellites to supplement said service of said geostationary satellite until a predetermined number of said medium earth orbit satellites have been launched, after which providing radiocommunication service using said geostationary satellite to supplement service of said medium earth orbit satellites.

9. A satellite communications system for serving a number of ground-base terminals with varying activity levels comprising:

a geostationary satellite disposed so as to be visible from the service area 24 hours a day;

at least one sub-synchronous satellite in an orbit having a repeating ground track timed to cover said service area at times of expected peak activity of said ground-based terminals.

10. The communications system of claim 9 further comprising a central ground station in communication with said geostationary satellite and with said sub-synchronous satellite when visible for relaying signals between the public switches' telephone and said terminals via at least one of said satellites.

11. The communications system of claim 10 further comprising control means to steer antenna spot beams of said geostationary satellite to locations momentarily not adequately served by said at least one sub-synchronous satellite.

12. The communications system of claim 11 in which said control means is a beamforming computer.

13. The communications system of claim 12 in which said beamforming computer is located at said central station.

14. A communications system for providing telephone communications between portable wireless terminals and the public switched telephone system via orbiting satellites comprising:

at least one geostationary relay satellite comprising an electronically steerable antenna;

at least one sub-synchronous relay satellite;

a tracking network for tracking the instantaneous position of said satellite and feeding information to communications gateway stations;

at least one communications gateway station connected to the PSTN and in communication with said at least one geostationary relay satellite, said gateway station comprising:

control means for controlling the areas illuminated by said steerable antenna's beams;

routing means for routing signals between said portable terminals and the PSTN via a satellite and antenna beam controlled based on information from said tracking network.

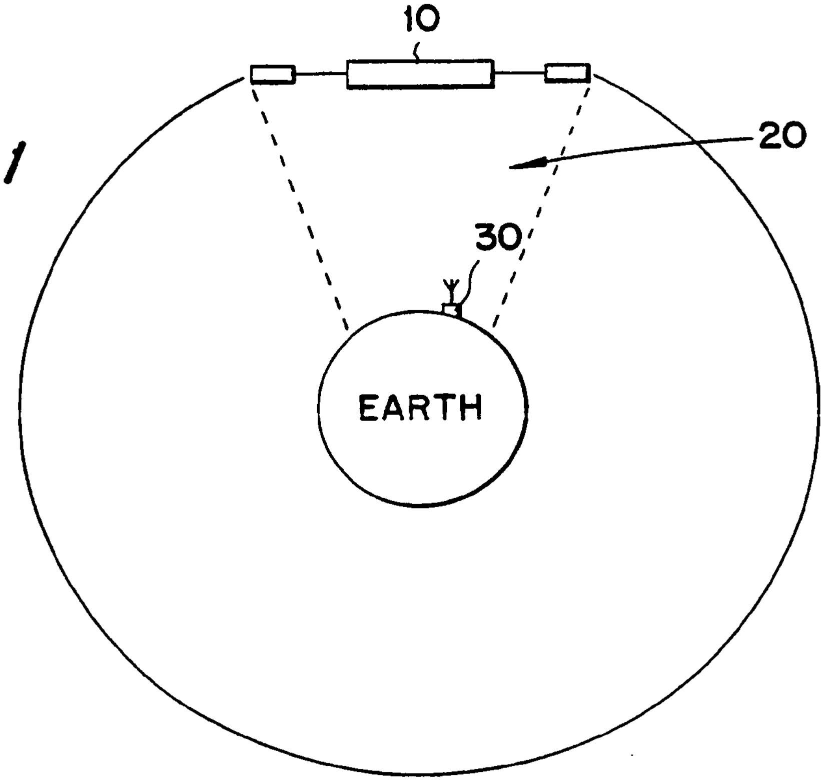

Fig. 1

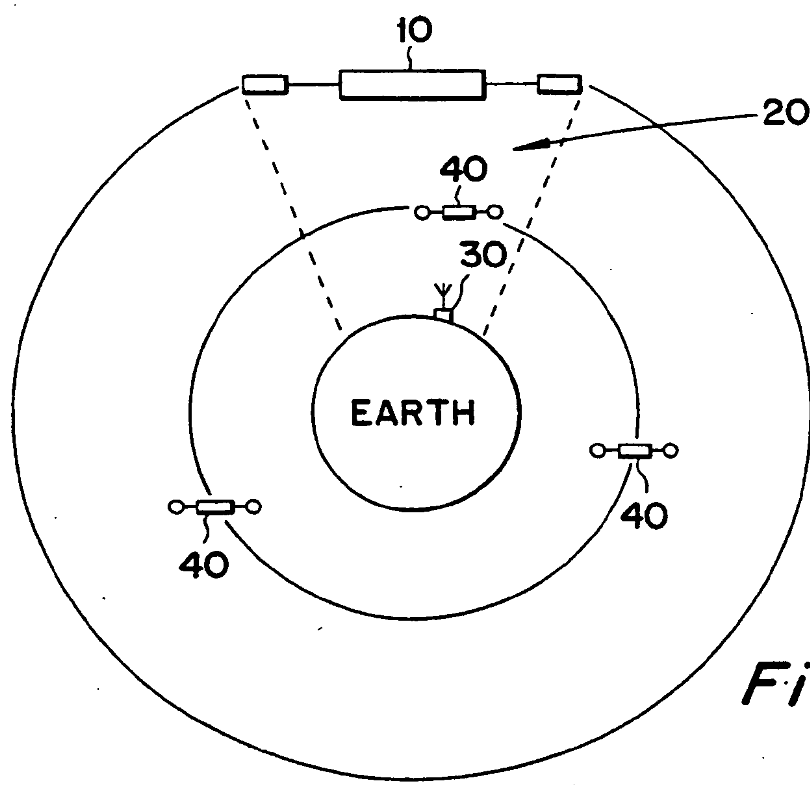

Fig. 2

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A. CLASSIFICATION OF SUBJECT MATTER
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 233 563 (ERNO) 26 August 1987 see claims ---	1-14
X	WO,A,88 04866 (MESSERSCHMITT-BÖLKOW-BLOHM) 30 June 1988 see claims; figure 1 ---	1-14
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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bischof, J-L

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 536 921 (SPACE SYSTEMS/LORAL INC.) 14 April 1993 see column 5, line 50 - column 7, line 12; figure 1 -----	14

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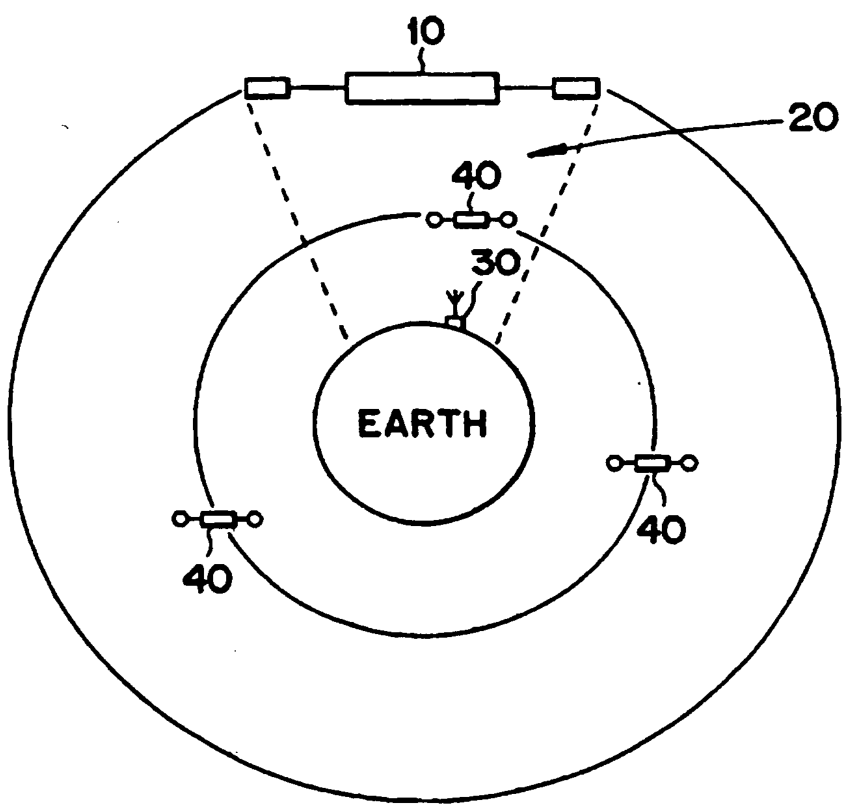

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Information on patent family members

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